

CALIFORNIA DIVISION OF MINES AND GEOLOGY  
FAULT EVALUATION REPORT FER-145

Faults East of Bakersfield, Kern County

by

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INTRODUCTION

This report summarizes the results of an evaluation of numerous east-west and northwesterly trending faults located east of Bakersfield in the Mt. Adelaide, Oil Center, Rio Bravo Ranch, Lamont, Bena (SW/4 Breckenridge Mountain 15' quadrangle), and Oiler Peak (SE/4 Breckenridge Mountain 15' quadrangle) 7.5-minute quadrangles (see Figure 1). Most of these faults are unnamed, but include the Edison and Kern Gorge faults. This fault evaluation is part of a state-wide effort to evaluate faults for recency of movement. Those faults determined to be sufficiently active and well-defined are zoned by the State Geologist as directed by the Alquist-Priolo Special Studies Zones Act (see Hart, 1980). The area studied encompasses ground ruptures mapped following the July 21, 1952, Arvin-Tehachapi earthquakes. These ruptures were previously zoned under the Act (California Division of Mines and Geology, 1976a; 1976b; 1976c).

SCOPE OF THIS INVESTIGATION

This investigation consisted largely of a review of the available literature (published and unpublished), interpretation of U.S. Department of Agriculture (1952) aerial photographs, and approximately two days of field reconnaissance. Earl W. Hart, Program Manager, accompanied this investigator on one of these two days of reconnaissance.

REGIONAL GEOLOGIC SETTING

The faults evaluated herein lie in the southern part of the Great Valley adjacent to the southernmost Sierra Nevada. To the south are the Tehachapi Mountains, a region where compressional stresses are dominant. To the east, the tectonic regime is one of extension. To the north lies the Sierra, a massive block of granitic terrain. To the northwest, along the western margin of the Sierra, extension also appears dominant, although the driving tectonic forces in that area do not appear to have caused nearly the magnitude of faulting as has occurred in the Basin and Ranges Province east of the study area.

The faults evaluated herein are generally northwesterly trending normal

faults, many of which have been active during Quaternary time. The relative displacement appears to be down to the southwest along most of these faults, but a few are down to the northeast. Thus, it appears that these faults are probably more closely related to the faults bounding the Sierra Nevada than to the compressional faults bounding the Tehachapi Mountains. In spite of this apparent relationship, earthquake-associated ground rupture reportedly occurred in 1952 along several of the faults evaluated herein (Bruer, Robinson, and others (1952)). During the same series of earthquakes, ground rupture also occurred along the White Wolf fault, a northeasterly trending, thrust or left-lateral reverse fault, located approximately 9 miles to the southeast. The tectonic relationship between the northwest trending normal faults east of Bakersfield and the northeast trending White Wolf faults apparently has not been studied, perhaps because the Bruer, Robinson, and others (1952) map is unpublished and has received little attention. However, the facts that aftershocks from the 1952 events occurred east of Bakersfield and that rupture occurred along the White Wolf fault suggest that these faults may all be tectonically related.

#### SUMMARY OF AVAILABLE INFORMATION

The original Special Studies Zones maps of the Edison, Oil Center, and Rio Bravo Ranch quadrangles (C.D.M.G., 1976a; 1976b; 1976c) were compiled by David L. Wagner. At the time these maps were produced, the Fault Evaluation Project staff were largely limited to using existing published and unpublished data, with virtually no time or money for purchase and interpretation of aerial photographs or for field reconnaissance (E. Hart, oral communication, 1984). Wagner relied heavily on the work of Bruer, Robinson, and others (1952) supplemented by the map of Wood and Dale (1964).

Bruer, Robinson, and others (1952) documented that surface fault rupture occurred in 1952 along several east-west and northwest-trending, sub-parallel faults in and near Ant Hill oil field and the Racetrack Hill area of Edison oil field (see Figures 2A, 2B, and 2D). They did not provide many details (such as amount of displacement, detailed pattern of fissures, etc.) on their map but did refer to an unpublished report [an attempt was made to locate a copy of this report, without success]. On their map they depict fissures associated with the 1952 earthquakes, classifying these fissures into one of three groups. Bruer (oral communication, 1983) indicated that the Group A fissures were most probably produced by fault rupture; other fissures observed (Group C) probably were caused by ground failure due to shaking. The cause of Group B fissures could not be clearly determined.

According to Bruer, Robinson, and others, (1952) most of the 1952 ruptures evaluated herein exhibit vertical displacement, primarily NE-block down but a few displacements were NE-block up. Two photographs of ruptures in Section 36, T. 29 S., R. 29 E., and Section 3, T. 30 S., R. 29 E., taken after the 1952 event show minor displacement and/or ground cracking. Based on these photographs, and considering the lack of published information on the 1952 ruptures evaluated herein, it appears reasonable to assume that the displacements on the fault ruptures evaluated were all relatively minor (that is, the displacements did not exceed a few inches even where the displacements were

the greatest). All other available references (e.g., Jennings, 1975) cite Bruer, Robinson, and others or the existing SSZ maps as the source of the 1952 rupture data.

Published geologic maps of the region vary in detail; however, most show several northwesterly trending faults in the same general area as the 1952 breaks (Figures 2A through 2E). The two principal references most frequently cited as sources of these fault data are an unpublished map by Dibblee (1952) and a published map by Wood and Dale (1964). Subsequent workers (e.g., Bartow and Doukas, 1978; Bartow, 1981; Jennings, 1975) have used a combination of either the Wood and Dale or Dibblee maps along with the Bruer, Robinson, and others map to compile regional geologic maps. Both Dibblee (1952) and Wood and Dale (1964) depict some faults as cutting older alluvium (see Figures 2A through 2E). Numerous other faults cut Plio-Pleistocene units described variously as Kern River Formation or Chanac Formation.

According to Hart, most of the Group A fissures of Bruer, Robinson, and others (1952) were depicted on the SSZ maps of 1976 because of Bruer's statement that Group A fissures were probably tectonic in origin and because they appeared to be associated with faults mapped by Wood and Dale (1964). On this basis, it was assumed that the more linear zones of Group A fissures were caused by fault rupture. In compiling the SSZ maps, group A fissures were supplemented with selected faults from Wood and Dale.

The Edison fault is one of two major faults in the study area. Dibblee and Chesterman (1953) depict the Edison fault as a normal fault dipping from  $28^{\circ}$  to  $60^{\circ}$ N. Based on the work of Wood and Dale (1964), Jennings (1975) depicted the westward subsurface extension of the Edison fault (Figures 2C, 2D, and 2E) as cutting Quaternary deposits. However, Bartow and Doukas (1978) indicate that the Edison fault cuts the Bealville fanlomerate (Miocene-Oligocene in age according to Dibblee and Chesterman, 1953) but does not cut Pleistocene alluvium at the surface (Bartow and Doukas do not show subsurface faults). Based on subsurface data, Barnes (1966) postulated that several subsurface faults lie very close to the trace of the Edison fault inferred by Wood and Dale (1964; see Figure 2D). Barnes believed that there were two episodes of fault movement evident in the area of Edison oil field. The initial, major episode of uplift occurred prior to the deposition of any Tertiary sediments. This was followed by a second episode of uplift and tilting during mid-Pleistocene time. Based on his cross-section, cumulative dip-slip displacement of the top of the Kern River-Chanac oil zone (Miocene to Pleistocene in age) amounts to 600 feet, northeast side down, across these two faults. The cumulative displacement of the unconformity on top of the basement amounts to about 1500 feet based on this same cross-section.

The second fault of structural significance is the Kern Gorge fault. Dibblee (1952) depicts the fault as the boundary between granitic rocks to the northwest and Quaternary terrace deposits to the southeast at the mouth of Kern Gorge. According to Bartow (1981) and Bartow and Doukas (1976; 1978), however, the Kern Gorge fault is concealed by talus and Pleistocene terrace deposits and is not shown as cutting any unit younger than the Round Mountain Silt (Miocene in age). Dibblee and Chesterman (1953) described the fault (which they referred to as the Kern River fault) as a southwesterly dipping

(55° to 80°) normal fault, locally marked by a 2-foot wide gouge zone with vertical grooves. At the mouth of Kern Gorge, the fault is evident as a prominent, 2,000-foot high scarp in resistant granitic materials. Jennings (1975) concluded that the fault does not cut any Quaternary deposits.

In the vicinity of Kern Bluff oil field, Corwin (1950) mapped an east-west trending normal fault (Figure 2A, Section 12, T. 29 S., R. 28 E., and Section 7, T. 29 S., R. 29 E.). He indicated that this fault dips about 60° south. Total displacement of the Kern River-Chanac (which he indicates is Pliocene in age) amounts to about 260 feet. Bartow and Doukas (1976) depicted the extension of this fault as cutting Pleistocene alluvium. Corwin (1950) also mapped a second normal fault in Sections 7 and 18, T. 29 S., R. 29 E. (Fig. 2A). He described this fault as dipping to the southwest, and having displaced the Kern River-Chanac by about 60 feet. Bartow and Doukas (1976) depict this fault as cutting Pleistocene alluvium. Although Figure 2A suggests that these two faults might be the same as those mapped by Bartow and Doukas, it should be noted that Corwin's fault locations are on horizons about 1000 feet below the surface and thus would project to the surface 500 feet or more away from the faults shown.

Bailey (1947) described the Ant Hill oil field as a westward plunging anticlinal nose upon which minor folding and faulting has been superimposed. All of the faults he mapped are normal faults. Most of the faults Bailey mapped do not appear to be related to the faults mapped at the surface by Bartow and Doukas (1978), Wood and Dale (1964), and Bruer, Robinson, and others (1952); however, one of Bailey's subsurface faults, if projected to the surface, nearly coincides with one of the 1952 ruptures in Section 22 (Figure 2B) and appears to have the same sense of displacement as the 1952 rupture (southwest side down). Based on Bailey's cross-sections, it appears that about 200 feet of post-Miocene displacement has occurred along this particular fault.

All other faults and information on recency and sense of offset shown on Figures 2A through 2E are based on maps of Bartow (1981) or Bartow and Doukas (1976; 1978). Some of these faults are depicted as cutting or inferred to cut Pleistocene deposits and others are not. None are shown to offset Holocene deposits. These maps lack any text which would describe these faults more fully.

Reports of site-specific investigations (Park and Smith, 1976 [AP-263]; 1977c [AP-1348]; 1978b [AP-1030]; 1978c [AP-950]; 1979c [AP-1000]; and Park, 1978 [AP-887]) have documented that faults do exist within the existing SSZ in the area evaluated herein (see Figure 2B). Most of these faults appear to be normal faults with northwest strikes and dips of 52° to nearly 90°. Three of the reports (AP-263, AP-887, and AP-950) document apparent displacement of the base of the soil horizons, which in one place appeared offset 4 to 6 feet (Fig. 2B, Sec. 16, T. 29 S., R. 29 E.). Widths of the individual fault zones are reported as up to 68 feet wide indicating repeated past displacements. These and other pertinent data presented in the unpublished consulting reports are summarized in Table 1. Some of these site-specific investigations have detected recent faults located away from the faults plotted on the 1976 SSZ maps (but still within the SSZ; Figure 2B). These faults are discussed in

more detail below.

#### INTERPRETATION OF AERIAL PHOTOGRAPHS

U.S.D.A. (1952) aerial photographs of the study area were interpreted in order to detect features indicative of recent fault movement. Annotated results are plotted on Figures 3A through 3E. Some of the faults which presumably coincide with the 1952 breaks reported by Bruer, Robinson, and others (1952) could not be identified on the photos even though only a few months had elapsed between the earthquake sequence and the time the photos were taken. Other ruptures were marked locally by scarps, tonal lineaments, or both. Some of these scarps locally have been trenched and identified as coinciding with recently active faults that are not shown on the SSZ maps (AP-950, Sec. 16, T. 29 S., R. 29 E., for example). Other morphologically similar scarps that trend subparallel to those already zoned, lie outside the SSZ in the Oil Center quadrangle (Figure 3A).

In the Edison quadrangle (Figure 3D) several sharp, south-facing scarps are visible. While one of these scarps coincides with a 1952 break in the Racetrack Hill area of Edison oil field, others lie roughly between two 1952 breaks (Sec. 1, T. 30 S., R. 29 E.) and are outside the present SSZs. Some of these scarps coincide with the contact between two Pleistocene alluvial units (Bartow and Doukas, 1976). Except for these apparent depositional contacts, based on the sharpness of the unzoned scarps, their similarity with the 1952 breaks, and their orientations across a few alluvial fans, it appears likely that these features are all fault produced.

Aerial photographs of the Edison fault were not available for interpretation except along part of the Wood and Dale (1964) inferred trace (Figures 2D and 3D). In the area covered, Late Pleistocene fan deposits do not appear to be offset by any faults.

The Kern Gorge fault is evidenced by an impressive high (400 to 600 foot) escarpment suggestive of substantial down-to-the-west displacement during Quaternary time (Figure 3B). No small features (such as scarps a few feet high) were observed that would suggest that recent (Holocene) fault movement has occurred on the Kern Gorge fault, although the lower part of the scarp is partly covered with talus deposits.

#### FIELD OBSERVATIONS

Two days were spent in the field in an attempt to detect features indicative of recent fault movement. Earl W. Hart, Program Manager, accompanied this investigator on one of these days.

Few of the 1952 breaks mapped by Bruer, Robinson, and others (1952) could be verified because more than 30 years has passed since the Kern County earthquakes occurred. Theoretically, had the displacements along these faults been very large, they should have been evident on the 1952, post-earthquake, aerial photographs and probably would have been prominently featured in Oakeshott

(1952). Since this did not occur, one must assume that all of the displacements were small. Thus, agricultural activities, oil field development activities, and urbanization, as well as natural processes, could have easily obliterated the evidence of the 1952 fault ruptures. Despite these difficulties, some of the larger geomorphic features (principally scarps) associated with the reported breaks were identifiable. These localities are noted on Figures 3A, 3B, and 3D. At locality 6 (Figure 2B), for example, a scarp trending approximately N. 42° W. and facing northeast was noted. At the point of its greatest height this scarp is over 6 feet high, slightly rounded, and about 25 feet wide. Locally it is only 2 feet high but appears quite sharp. Numerous mounds (probably debris from animal burrows) are present on the northeastern side of the scarp. No open fractures were observed. The remnants of a trench were observed crossing the feature (this site investigation has not yet been filed with CDMG). Based on the features observed it appears that the sharp, 2-foot high portion of the scarp probably reflects the most recent fault displacement, while the higher portions of the scarp suggest that fault movement has recurred along this same feature. In 1952, fault ruptures were reported along part of this feature.

At locality 7, a similar scarp, also about 6 feet high was observed. This scarp appears to be slightly dissected, and is nearly parallel (N. 45° W.) to the former scarp. Both scarps appear to die out northwestward in areas of slightly undulating topography. Again, no open fractures were observed.

The scarp at locality 8 (Figure 3B) appear to have been obliterated by plowing in its central segment. Remnants of this southwest-facing scarp were observed only at the northern and southern ends of the scarp identified on the photos. No open fractures were noted, although 1952 ruptures were reported along this trend.

To the southwest, at locality 10 (Figure 3B), no scarp was evident across a modern drainage. Thus, this scarp appears to be a dissected remnant of an older fault.

A low, well-defined scarp was evident at locality 11 (Figure 3D). This scarp could be followed as a continuous feature for about half a mile and was evident across two Holocene fans. Where the scarp crossed these fans, it ranged in height from about 3 inches to 6 inches. This scarp was not visible on the aerial photographs. However, a scarp was observed on the photos but occurs farther upslope, and reflects the presence of a resistant conglomerate bed, the outcrop of which does not coincide with location of the fault. Based on these observations, it appears that the fault trace shown on the existing SSZ map is correctly located.

Access could not be obtained to all of the scarps east of the Racetrack Hill area of Edison oil field (Figure 3D). However, considering the lack of diagnostic exposures and features in the areas checked (locality 1), it appears unlikely that additional information critical to this evaluation effort would be obtained, since the area has been modified by farming.

A brief reconnaissance of the Edison fault also was made. Here, again, the fault was not exposed in any road cuts. It appears, based on the mapping

of Dibblee and Chesterman (1953) and observed differences in vegetation (green vs. not so green grasses) that locally the fault acts as a water barrier. The hillslopes north of State Highway 58 (see Figure 2E) lack any scarps along the Edison fault that would suggest that normal faulting has occurred during late Quaternary time.

#### SEISMICITY

As noted above, ground-rupture occurred along several of the faults evaluated herein in 1952. Richter (1955) reported that a series of earthquakes began on July 21, 1952, and that these earthquakes were confined to the area of the White Wolf fault (south of the study area) until the night of July 28-29 when a large (M 6.1) shock and several smaller ones occurred just east of Bakersfield. On August 22, a M 5.8 earthquake also occurred in this same area.

The proximity of the 1952 fault breaks evaluated herein to the large aftershocks is suggestive of a cause and effect relationship (see Figure 4). However, Bruer (oral communication, 1983) indicates that the ruptures in this area were found after the July 21 earthquakes and before the July 28-29 earthquakes. It is conceivable that ground rupture east of Bakersfield may have been associated with more than one earthquake.

#### CONCLUSIONS

Bruer, Robinson, and others (1952) identified several, fairly linear zones of "earthquake fissures" in the area studied herein following the 1952 Kern County earthquake of July 21, 1952. Their map provides no information on the magnitude of the displacements, although they generally indicate the sense of offset of rupture zones. Two photographs of Bruer (unpublished) show fissure openings and vertical slip to be no more than a few inches at two locations in the Edison quadrangle, suggesting that magnitudes of displacement were small.

Based on the their map, CDMG zoned the linear zones of fissures because of the continuity shown by Bruer, Robinson, and others, because Bruer identified them as being similar to other fault-related fissures, and because Wood and Dale (1964) identified faults along the same trends as the 1952 fissures.

As earlier noted in Table 1, subsequent site-specific investigations confirm that the fissures reported by Bruer, Robinson, and others are associated with normal faults in several places and are reasonably well-located on the SSZ maps. In addition, scarps and tonal lineaments locally coincide with the reported fissures, based on the information developed during this investigation. Therefore, it appears probable that fissures reported by Bruer, Robinson, and others, which are already zoned for special studies, were tectonically produced and are fairly accurately located. Certainly, the data summarized herein are insufficient to justify deleting any of the 1952 ruptures from the Special Studies Zones. However, based on several site-specific investigations, minor relocation of some of the traces appears warranted.

It appears that some of these recently active faults extend beyond the boundaries of the Special Studies Zones, especially in the area northwest of State Highway 178. This conclusion is primarily based on the presence of geomorphic features (principally scarps) similar to those found along some of the 1952 fissures which were later confirmed by trenching to be faults. Indeed, some of these scarps are actually extensions of scarps that have been trenched and found to coincide with normal faults. Based on the similarity (particularly the degree of dissection) of the scarps trenched to those reasonably well-defined scarps not yet zoned, it appears likely that movement has occurred along these unzoned extensions during Holocene time, and almost certainly occurred during latest Pleistocene time.

Also, based on the field observations, the morphology of the scarps northwest of Ant Hill oil field suggests that repeated movement has occurred along at least one of the faults evaluated herein.

No other faults appear to be sufficiently active to warrant zoning, even though they might be well defined locally. This includes the Kern Gorge fault, which in part may owe its rather impressive fault scarp at the mouth of Kern Gorge to differential erosion rather than recent (late Quaternary) faulting, and the Edison fault. It appears the latter fault has long been inactive since it is not known to displace any Quaternary units and lacks any geomorphic features indicative of recent normal displacement.

#### RECOMMENDATIONS

Based on the above information and conclusions, revision of the existing SSZ maps of the Oil Center, Rio Bravo Ranch, and Edison quadrangles appears warranted. Figures 5A, 5B, and 5C show the recommended revised zones. Bruer, Robinson, and others (1952) and this FER should be the principal references cited.



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*I have reviewed this report, the air photos and field-checked locally and concur with recommendations. Zones should be drawn as narrow as confidence in trace locations permit, as none of the faults appear to be major active faults.*

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FER-145. Table 1. Summary of results of site-specific investigations the reports of which are filed with the State Geologist. Locations of sites and trenches are shown on Figures 2B, 2C, and 2D.

| <u>File No.</u> | <u>Investigators, Date, &amp; Firm Name</u>        | <u>Results of Investigation</u>   |
|-----------------|--|---|
| C-82            | Park 1975<br>Bryant-Park & Associates              | No faults found.  |
| C-83            | Park & Smith, 1975<br>Bryant-Park & Associates     | No faults found.  |
| AP-263          | Park & Smith, 1976<br>William H. Park-Geologist    | Two normal faults (N 40° W, vertical dip, east-side down; N 65° W, 75° NE dip) with 24" of vertical displacement found.   |
| AP-263          | Park & Smith, 1978a<br>William H. Park-Geologist   | Fault zone 8 to 20' wide observed; base of soil horizon offset, NE-side down.   |
| AP-375          | LaPerle, 1976<br>Western Continental Operating Co. | No faults observed in trenches; cites faults found by Park nearby; recommends setbacks.   |
| AP-375          | Park & Smith, 1978d<br>William H. Park-Geologist   | No faults observed.   |
| AP-458          | Park & Brooks, 1976<br>William H. Park-Geologist   | No faults observed.   |
| AP-551          | Park & Smith, 1977a<br>William H. Park-Geologist   | No faults observed.   |
| AP-609          | Park & Smith, 1977b<br>William H. Park-Geologist   | No faults observed.   |
| AP-887          | Park, 1978<br>William H. Park-Geologist            | Numerous normal faults, down-thrown to east, observed trending about N 52° E. Zone is about 68 feet wide. Base of soil horizon offset.  |
| AP-950          | Park & Smith, 1978c<br>William H. Park-Geologist   | Normal fault, trends N 40° W, dips 78° SW, base of topsoil offset about 4 to 6 ft; surface features modified. Scarp to NW on trend is coincident with fault striking N 50° W, vertical dip, down to NE (off property investigated). |
| AP-957          | Park & Smith, 1979a<br>William H. Park-Geologist   | No faults observed.   |

FER-145. Table 1 (continued).  
AP-992 Park & Smith, 1979b  
William H. Park-Geologist

No faults observed.

AP-1000 Park & Smith, 1979c  
William H. Park-Geologist

Two fault zones found. First zone (SW-most) trends N 54° W, forming a 15' wide graben; second zone trends N 62° W, downthrown to NE, and is about 70' wide. Second zone is "not distinct", however.

AP-1030 Park & Smith, 1978b  
William H. Park-Geologist

Faults identified but logs do not show offset of base of soil horizon. Some "faults" would appear to be pull-apart features.

AP-1348 Park & Smith, 1977c  
William H. Park-Geologist

Fault trending N 30° W, vertical dip, downthrown to NE. Plio-Pleistocene deposits offset at least 20 ft. Soil does not appear offset on log.

AP-1481 Smith, 1982  
William H. Park-Geologist

No faults observed.

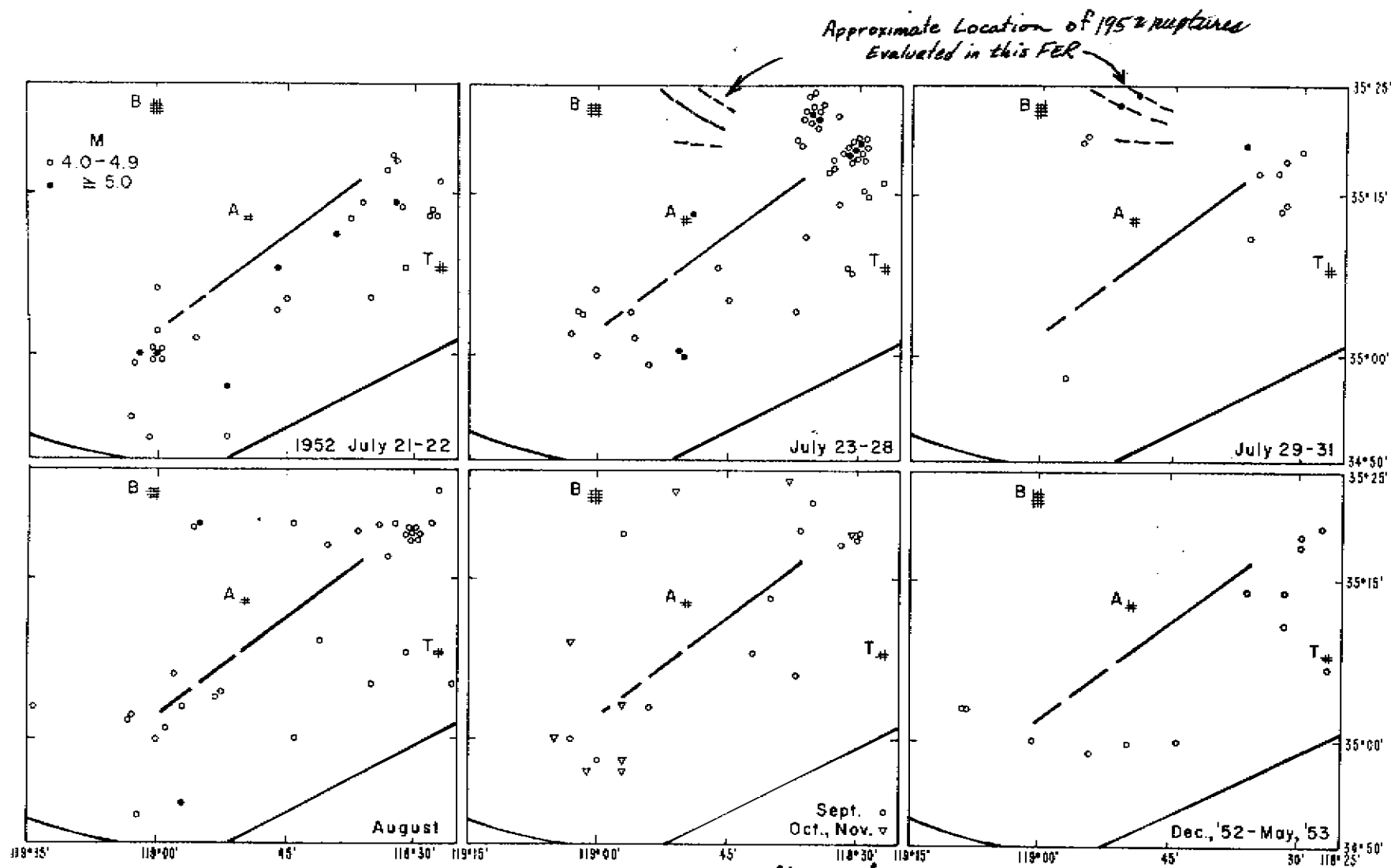
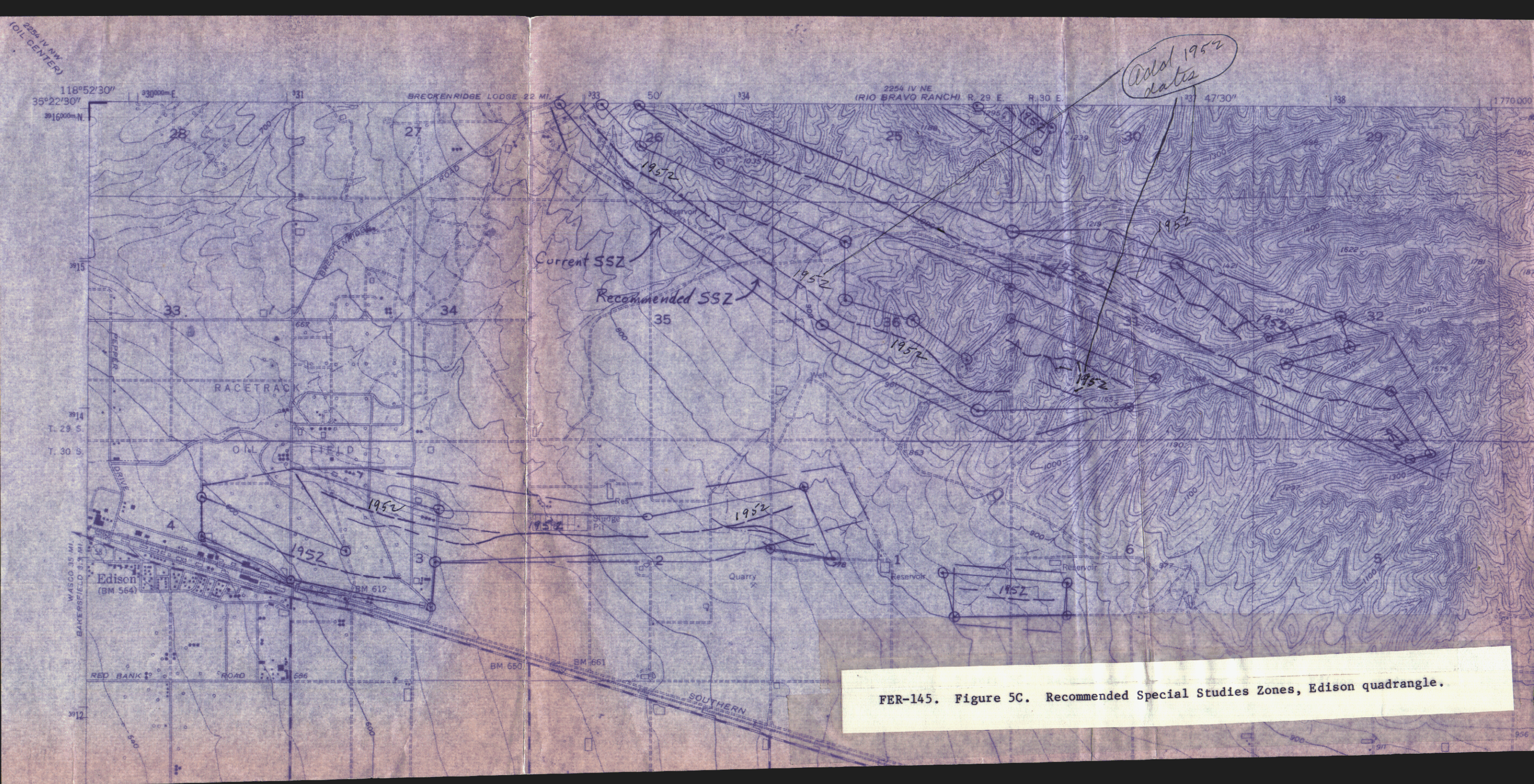


FIGURE 2. Epicenters of located shocks of magnitude 4.0 and over: (a) 1952 July 21 11:52—July 23 00<sup>h</sup>; (b) July 23 00<sup>h</sup>—July 29 00<sup>h</sup>; (c) July 29-31; (d) August; (e) September, October, November; (f) December 1952 through June 1953.

FER-145. Figure 4. Epicenters of earthquakes magnitude 4.0 and larger (from Richter, 1955).





FER-145. Figure 5B. Recommended Special Studies Zones, Rio Bravo Ranch quadrangle.

